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THE SALT TOLERANCE OF RICE[1]

George A. Pearson[2]

Soluble salts may be removed from a saline soil by leaching (washing down) with water of low salt content. In practice, saline soils are usually reclaimed by ponding water on the surface of the soil in order to assure a net downward movement of water and salt. Because rice can tolerate submerged conditions, it is sometimes grown while leaching saline soils. The success or failure of such a practice, however, depends upon the ability of rice to grow on saline soils. Additional information concerning the salt tolerance of rice has been obtained from several experiments conducted at the U.S. Salinity Laboratory (3, 5).

These experiments have been conducted in both sand and soil cultures. Sand cultures were used by Ayers and Eberhard of this laboratory to study the effect of salinity during germination and early seedling development. The results, as yet unpublished, indicated that rice was able to germinate in solutions which were very saline (electrical conductivity in excess of 20 millimhos/cm., or approximately 12,000 parts per million). However, at the age of one week to 10 days, the young seedlings, grown in artifically salinized soil, could tolerate only about three to four millimhos/cm. in the soil solution (3). Varietal differences have been noted with respect to salt tolerance at the early seedling stage of growth. For example, Kala-Rata (India) survived at somewhat higher salinity levels than Agami Montakhab I (Egypt), Asahi No. 1 (Japan), or Caloro (United States).

Our experiments have indicated that plant growth on saline soils is related to the salt concentration in the soil solution in the active root zone (6). A periodic measurement of the electrical conductivity of the soil solution throughout the growing season provides an easy and accurate appraisal of the salinity status of the soil. The expression of soil salinity in terms of percent salt on a dry-soil basis is meaningless without a value for the saturation percentage of the soil, i.e. the amount of water in which the salt is dissolved in a saturated paddy field.

In connection with the soil cultures, a method was devised for regulating the rate of downward movement of water through a submerged soil (3, 4). In this way, it was possible to keep the soil submerged and at the same time permit some leaching. It was found that the conductivity of the soil solution increased as the electrical conductivity of the applied irrigation water increased, or as the rate of water movement through the soil decreased. Salts present in the soil before flooding were moved downward and had

1 A contribution of the U.S. Salinity Laboratory, Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Riverside, California, in cooperation with the 17 Western States and Hawaii and the International Cooperation Administration, Washington, D.C. Based on a report presented to the Seventh Meeting of the Working Party on Rice Soils, Water and Fertilizer Practices of the International Rice Commission held at Peradeniya, Ceylon, December 14-19, 1959.

2 Plant Physiologist.

relatively little influence on the final salt concentration in the soil solution. The conductivity of the soil solution was always greater than that of the irrigation water. This was due to the loss of water by evapo-transpiration without a proportionate loss of salt. Since the evapo-transpiration rate may vary throughout the season and the percolation rate (downward movement of water) may not be known, it is difficult to predict the salinity status of a soil from the salt content of the irrigation water alone. The salinity status of a soil, therefore, is based upon periodic measurements of the electrical conductivity of the soil solution in the active root zone during the growing season.

The containers selected for the soil cultures were of sufficient size to permit a surface area of 160 sq. cm. for each of the 10-12 plants grown. Thus, it was possible to grow the rice plants to maturity and determine the effect of salinity on grain production, as well as other growth criteria. The data on plant growth indicated that after the young seedling stage (2 to 3 leaves) the salt tolerance of rice progressively increased until the time of flowering. For example, sprouted Caloro seed did not grow at soil salinity values in excess of approximately 4 millimhos, whereas 3- and 6-week-old seedlings survived at soil salinity values up to about 9 and 14 millimhos/cm., respectively (3). It has been shown that this increase in salt tolerance during the tillering and elongation stages is not due simply to the decrease in the length of time the plant is grown under saline conditions (5).

Japanese workers (1,2) have reported that salinity had an adverse effect on the germination of pollen grains which resulted in an increase in the number of sterile florets per panicle. After flowering, however, salinity apparently had little effect on the yield of rice.

Thus, it appears that rice is very salt tolerant during germination but very sensitive at the 1-to 2-leaf stage. The salt tolerance of rice progressively increases during the tillering and elongation stages of development and again decreases at the time of floret fertilization. Maturation of fertilized florets is apparently unaffected at the salinity levels encountered in these studies.

It has also been found that salinity does not affect all criteria of growth to the same degree, i.e. vegetative growth is less seriously affected than grain production (3). At a relatively high level of salinity (11 mmhos.), the approximate reduction in growth of Caloro rice expressed as a percentage of growth obtained on a nonsaline treatment (2 mmhos.) was as follows: Height, less than 25 percent; dry weight of straw, 33 percent; number of mature tillers, 50 percent; number of panicles and dry weight of grain plus straw, 66 percent; and weight of mature, filled grain, 95 percent. In more recent experiments, a progressive decrease in length of panicle and percent fertilization of florets was noted with an increase in salinity. The very drastic reduction in the yield of grain was probably due to a compounding of the reduction in the number of tillers and panicles, length of panicle, and percent fertilization of florets.

At the present time, the relative salt tolerance of several rice varieties is being determined. These varieties include Agami Montakhab I (Egypt), Arroz Portugues (Portugal), Asahi No. 1 and Norin No. 18 (Japan), Dhoke and Kala-Rata (India), and Bluebonnet, Blue Rose, B 4512 Al-32, Caloro, Calrose, Century-Patna 231, Colusa and Zenith (all United States). The experimental technique is the same for all varieties so that it may be possible to establish the relative salt tolerance of these varieties on a quantitative basis.

As in the case of salinity effects during the early seedling stage, there is evidence that the grain production of all varieties is not affected to the same degree. Preliminary results indicate that, with respect to grain production, Agami Montakhab I appears to be somewhat more salt tolerant than Asahi No. 1, Kala-Rata, or Caloro, but the differences noted among any of the varieties mentioned were small. This ranking of varieties differs from the one previously mentioned for the relative salt tolerance during the early seedling stage.

At the U.S. Salinity Laboratory, the salt tolerance of crops is based on the relationship between yield and the electrical conductivity of the saturation extract (EC_e), a measurement which may be readily obtained (6). The yield of a salt-sensitive crop is reduced 50 percent at EC_e values up to 4 mmhos./cm. Since the moisture content of a soil at field capacity is approximately one-half as great as at saturation, the electrical conductivity of the soil solution at field capacity is approximately twice as great as at saturation. Therefore, the yield of a salt-sensitive crop normally grown at moisture contents equivalent to field capacity or less is reduced 50 percent at electrical conductivity values up to approximately 9 mmhos./cm. under field conditions.

The yield of Caloro rice grain was reduced 50 percent at an electrical conductivity value of 8 mmhos./cm. in the saturation extract. Since rice is normally grown in saturated soil, the saturation extract represents the soil solution as found under field conditions. On this basis, rice should be considered a salt-sensitive crop.

The ability of rice to grow on soils, presumed to be saline, may be related to management practices employed. For example, salts initially present in the field, as indicated by a white crust on the surface of the soil, may be leached beyond the root zone during the plowing and levelling operations, at which time the field is submerged. Also, transplants, which are usually 4 to 6 weeks of age, are able to survive at higher salinity values than younger seedlings.

Summary

The salinity status of a soil can be easily and accurately expressed in terms of the electrical conductivity of the soil solution in the root zone.

Soluble salts present in a slowly permeable soil should be moved downward when the soil is submerged. These salts may have relatively little influence on the growth of rice transplanted in these soils some time after submergence.

The salt concentration of the soil solution is usually greater than the salt concentration of the irrigation water being applied. This increase is related to the loss of water by evapo-transpiration.

The effect of salinity on the growth of rice depends upon the stage of development at which the salinity occurs. Rice is apparently most tolerant to salinity during the germination stage and most sensitive during the young seedling stage (1 to 2 leaves).

The degree to which rice is affected by salinity depends upon the criterion measured and the variety involved. Among the varieties tested at the U.S. Salinity Laboratory, vegetative growth is less seriously affected than grain formation. On the basis of the grain yield, none of the varieties tested should be considered a salt-tolerant variety.

The salt tolerance of a particular variety of rice, should be based on the relationship between grain production and the electrical conductivity of the soil solution in the root zone during the growing season.

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A TECHNIQUE FOR DETERMINING THE SALT TOLERANCE OF RICE[1]

George A. Pearson 2

The salt tolerance of a crop is based on the relationship between the salt concentration in the soil solution and the yield of the crop (4). Difficulties may be encountered, however, in regulating the salinity status of a submerged soil such as used in rice cultures. The purpose of this paper is to discuss a technique which has been used at the U.S. Salinity Laboratory and found satisfactory in such cases (1).

In general, the technique consists of growing rice in containers of soil which are flooded according to accepted management practices. Drums, crocks or conventional lysimeters may be used as soil containers, but must have an opening at the bottom for drainage. The rate of water movement downward through the soil is regulated to any desired value less than the normal percolation rate of the soil. Waters of known salt content are applied and the electrical conductivity and ionic composition of the soil solution in the root zone determined periodically during the growing season. A diagram is presented in figure 1.

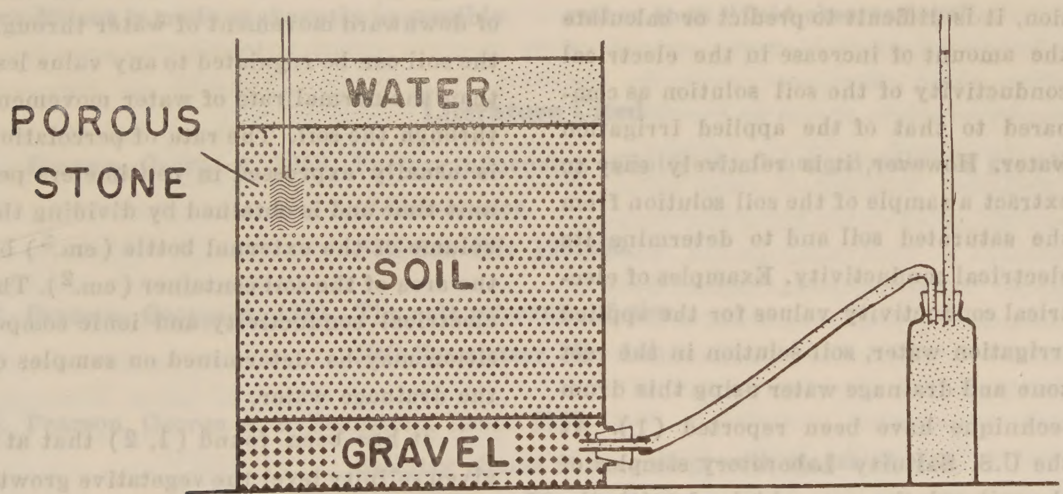

Figure 1. Diagram of soil container showing porous stone for removing soil solution samples, gravel layer, and bottle used to control the volume of soil solution displaced.

1 Contribution from the U.S. Salinity Laboratory, Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Riverside, California, in cooperation with the 17 Western States and Hawaii and the International Cooperation Administration, Washington, D.C.

2 Plant Physiologist.

Saline irrigation waters are prepared by adding calculated amounts of salt to water having a low initial salt content. The salinity status of the water is determined by measuring the electrical conductivity before applying it to the soil. The ionic composition of the irrigation water may be varied by suitable selection of salts added to the water. In general, chloride salts are preferred because of their greater solubilities.

The electrical conductivity of the soil solution in the root zone will be greater than the electrical conductivity of the irrigation water applied. This is due to the loss of water by evapo-transpiration without a proportionate loss of salt. Because of variations in the climatic conditions regulating evapo-transpiration, it is difficult to predict or calculate the amount of increase in the electrical conductivity of the soil solution as compared to that of the applied irrigation water. However, it is relatively easy to extract a sample of the soil solution from the saturated soil and to determine its electrical conductivity. Examples of electrical conductivity values for the applied irrigation water, soil solution in the root zone and drainage water using this drum technique have been reported (1). At the U.S. Salinity Laboratory samples of the soil solution are obtained with the aid of a porous stone (aquarium aerator) approximately 1.5 cm. in diameter and 2.5 cm. long. Suction is applied to a tube which is sealed in the porous stone and extends to a point above the free-water surface. These stones are placed permanently at any desired location in the drum and used throughout the course of the experiment.

Gravel is placed in the bottom of the drum to aid in the vertical movement of water. In order to assure a uniform distribution of salt in the soil, it is important that the soil solution moves straight down. After reaching the gravel layer, it will then move horizontally to the drainage outlet at the side. The drainage water from the drum fills the bottle and the vertical tube which projects upward to a point above the free-water surface in the drum. When the water in the vertical tube above the bottle reaches a point corresponding to the free-water surface in the drum, water movement from the bottom of the drum to the bottle ceases. After the bottle has been emptied, water will again move through the soil out of the drum and into the bottle. By changing the size of the bottle the rate of downward movement of water through the soil can be regulated to any value less than the normal rate of water movement through the soil. The rate of percolation is usually expressed in centimeters per unit time and is obtained by dividing the volume of the external bottle ($cm.^3$) by the area of the soil container ($cm.^2$). The electrical conductivity and ionic composition may be determined on samples of the drainage water.

It has been found (1, 2) that at a given salinity level the vegetative growth of rice is less seriously affected than the yield of grain. For this reason, it is necessary to actually determine the effect of salinity on grain yield rather than to attempt a prediction of the effect.

At the U.S. Salinity Laboratory the relative salt tolerance of crops is based on the relationship between yield and the average electrical conductivity of the soil

solution in the active root zone during the growing season. Increasing values for the electrical conductivity of the soil solution are achieved by adding increasing amounts of salt to the irrigation water. The electrical conductivity of the applied water is usually maintained constant during the period of differential treatment, but may be changed during the growing season to simulate field conditions. In the case of rice, it has been found that the effect of a given level of salinity will vary according to the age of the plant at which the salinity is imposed (2, 3). To simulate cultural practices in many areas, the seeds are planted in non-saline soil and maintained under such conditions for 4 weeks. At this time, saline irrigation waters are applied to the various cultures. The change from non-saline to saline conditions is made as abruptly as possible to simulate changes associated with transplanting from a relatively non-saline nursery bed to a saline field.

At the conclusion of the experiment, various growth measurements are recorded and these values plotted against the average electrical conductivity of the soil solution during the period of differential treatment.

Because of variations in growth regulating factors, such as photoperiod, all varieties of rice will not grow normally at a single location. Thus, it is sometimes necessary to compare the results of experiments conducted at widely separated locations. Such results might be compared with greater confidence, if they were based on experiments conducted according to a "standard" technique rather than "field observations".

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SUMMARY OF RESULTS OBTAINED UNDER THE COOPERATIVE BLAST RESISTANCE TRIALS[1]

The Sixth meeting of the working Party on Rice Breeding held in Malaya in December 1955, had recommended that "member countries should, wherever facilities exist, intensify their work on breeding new varieties resistant to blast disease; genetic stocks maintained at the four centres, with the exception of Indonesia, where blast disease does not occur, should be tested for susceptibility to blast in order to isolate resistant varieties: the Director, Central Rice Research Institute, Cuttack, should prepare for distribution a list of all resistant varieties available. In view of the possible physiologic specialization of the pathogen, all resistant varieties, wherever growing, should be tested in all countries where blast occurs and full information of the conditions under which they are grown in the country of origin should be furnished".

In pursuance of the above recommendation, information was collected regarding the availability of rice varieties resistant to blast from Burma, Ceylon, Egypt, India, Indonesia, Japan, Malaya, Pakistan, the Philippines, Taiwan, Thailand and the U.S.A. Arrangements were also made for the distribution of the seeds of resistant varieties to testing centres in Egypt, India, Japan, the Philippines, Taiwan, Thailand and the U.S.A.

Collaborators:

Egypt	– M.A. Koshairy Gad El Hak
India	– R.H. Richharia S.Y. Padmanabhan J. Veeraraghavan P.D. Das
Indonesia	– H. Siregar I.S. Dermoredje
Japan	– Toshitaro Morinaga Sakari Masuda Katsumi Amatatsu
Malaya	– F.B. Brown L.N.H. Larter
Philippines	– Eugenio E. Cruz D.L. Umali
U.S.A.	– C. Roy Adair H.M. Beachell

Methods of assessing the reaction of varieties to blast by participating countries–comparative assessment of data

The infection obtained in the tests, was scored to assess the susceptibility rating of the test varieties. The procedure adopted in this respect by the different countries differed slightly, and for the purpose of comparison, the various systems adopted for the assessment of infection in the four countries were re-scored in terms of one system, namely, that suggested from India and the varieties were then classified on the basis of the reported infection scores from the various countries. The details of the method of conversion of the original scores and their interpretation are presented in Table I.

In the final classification of the varieties, the maximum degree of susceptibility obtained in any one of the infection tests in a country was taken as the expression of its genetic character in the test in that country.

1 Reported by the Director, Central Rice Research Institute, Cuttack, India.

TABLE I

Basis and Method of Interpretation of Infection Data received from India, Japan, the U.S.A. and the Philippines

Country	Data presented by participating countries	Interpretation based on system adopted at Central Rice Research Institute, India for co-ordination. Reaction of maximum susceptibility in any one of the tests during 1956-58 was taken into account.
India	Four degrees of susceptibility expressed: resistant, moderately resistant, moderately susceptible, and susceptible. This is based on observations in seedlings, tillering and heading stages for each variety in each crop season.	Data as presented were incorporated
Japan	Data on leaf infection in seedling phase and tillering phase presented indicating the amount and type of spots. In adopting this system of scoring Japan has followed system adopted in India. Data on neck infection have been expressed in four categories: resistant, moderately resistant, moderately susceptible and susceptible: basis of classification as in India.	In tests involving artificial infection either in seedling or tillering phase or both, numerical infection score was calculated and reaction derived. In tests done under natural conditions, type of leaf infection spot in seedling or tillering phase or both were taken into consideration and reaction derived. Reaction to neck infection of varieties incorporated as such from the original report.
The U.S.A.	Data on seedling infection, leaf infection in tillering phase and neck infection in nature expressed on a numerical scale 0,1, 2,3,4,5,6: 0 = No infection. 1,2,3 & 4 = Intermediate degrees of susceptibility. 5 = All leaves killed in seedling stage or all panicles blasted in flowering stage. 6 = Mortality.	0,1,2 = Resistant 3 = Moderately resistant 4 = Moderately susceptible 5,6 = Susceptible.
The Philippines	Data on neck infection in flowering stage, expressed in percentage of neck infection. Reference has been made to varieties showing 10 per cent and less percentage of neck infection as resistant and to varieties showing more than 50 per cent neck infection as susceptible.	Percentage of neck infection for each variety was taken into account for deriving the reaction of the variety as adopted in India.

The results from India, Japan, the U.S.A. and the Philippines are presented in Tables II (A) and II (B).

TABLE II (A)

Final Results of the Cooperative Blast Resistance Trial.

(Reaction of Varieties submitted as Resistant in Country of Origin)

Sl. No.	Country of Origin	World Genetic Stock No.	Name of variety	Japan	The Phillippines	The U.S.A.	India
1	2	3	4	5	6	7	8
1	Japan	249	Ishikareshiroke	S	R	MS	MS
2		577	Fujisaka-5	S	–	R	S
3		285	Norin-17	S	MS	MR	R
4		260	Norin-22	S	MS	MR	R
5		914	Kanto-51	S	MS	MR	S
6		270	Sensho	S	MS	MR	S
7		–	Pi-1	S	MR	MS	S
8		–	Reishiko	S	–	R	S
9		–	Toto	S	S	MR	S
10	Egypt	515	Nahada	–	–	MS	S
11		866	Agamimont	–	–	MS	S
12		867	Giza-14	S	–	MR	S
13	India		B.J.1.	S	–	R	R
14			SM.8	S	–	MS	MS
15			SM.6	R	–	MS	R
16			S.67	S*	–	R	R
17		751	Akp.8	S	–	S	MS
18		720	Akp.9	S	–	MR	MS
19		381	Co.4	–	–	–	R
20		721	Co.26	O	–	MS**	R
21	Indonesia	112	Peta	MR	MR	S	S
22		135	Bengawan	MR	R	MS	R
23		124	Intan	R	S	MS	S
24		111	Salak	MR	MR	MS	S
25		107	Tjahajha	MR	MS	MS	S

* S.67 was susceptible only in one out of five tests.

** The variety proved moderately susceptible only in one year during the flowering stage.

TABLE II (A) contd.

Sl. No.	Country of Origin	World Genetic Stock No.	Name of variety	Japan	The Philippines	The U.S.A.	India
1	2	3	4	5	6	7	8
26		–	Sigadis	MS	MR	MS	S
27		–	Ramedja	MS	R	MR	S
28		106	Tjina	MR	MS	MS	S
29	Malaya	145	Millek Kuening-3	MS	S	MS	S
30		157	Kontor	MS	S	MS	S
31		1064	Seriraja	R	MR	MS	S
32		146	Mayang Sagunpal	R	MS	MS	S
33	The Philippines	1093	Wag Wag	S	–	–	S
34		1088	Raminad Str.3	S	R	–	R
35	Taiwan	1096	Kwangfu-1	S	–	–	R
36		1094	Chianongyo-242	S	–	–	S
37		–	Chianonyo-280	S	–	–	R
38	The U.S.A.	206	Zenith	S	S	MS	R
39		1017	Lacrosse	S	S	S	MS
40			CI. 9045	S	S	MS	R
41			CI. 9075	S	S	MS	MS
42			CI. 9155	S	S	S	MR
43			CI. 9249	S	S	S	MS
44	Burma	20	A.28-8	–	–	–	S
45			A.29-20	–	–	–	S
46			B.43-11	–	–	–	S
47			B.47-5	–	–	–	S
48		59	C.24-71	–	–	–	S
49		46	C.24-102	–	–	–	S
50			C.34-1	–	–	–	S
51			C.28-16	–	–	–	S
52			D.402	–	–	–	S
53		33	B.24-92	–	–	–	S

TABLE II (B)

Final Results of Cooperative Blast Resistance Trial.

(Reaction of Varieties submitted as Susceptible in Country of Origin)

Sl. No.	Country of Origin	World Genetic Stock No.	Name of variety	Japan	The Philippines	The U.S.A.	India
1	Japan	289	Norin-1	S	R	R	R
2	Egypt	513	Nabatat Asmer	–	–	S	R
		869	Sabaini	–	–	S	S
4	India	345	Co.13	S	–	S	S
			GEB.24	–	–	–	–
			Adt.10	O	–	MS	–
7	Indonesia	116	Mas	MR	S	MS	S
8	Malaya	144	Nachin-11	MR	S	MS	S
9		143	Siam-29	MR	S	MS	S
10		150	Serendah Kuening	MS	S	MS	S
11	The Philippines	–	Buenketan	S	MS	MS	S
12		–	Thailand	S	S	S	S
13	Taiwan	–	Kunshan-Wushiangkeng	S	–	–	S
14	The U.S.A.	211	Caloro	S	R	MR	S
15		220	Fortuna	S	S	S	S

Discussion

From the results it may be seen that there is apparently a greater similarity between the results from India, U.S.A. and the Philippines, whereas the reactions of the varieties in Japan are different from those recorded in the other three countries.

For instance, Norin-17 and Norin-22 among the resistant group and Norin-1 which was received from Japan as susceptible, were resistant to moderately resistant in India and the U.S.A., while the former two were moderately susceptible in the Philippines where Norin-1 was resistant. B.J. 1 was resistant both in the U.S.A. and India but susceptible in Japan. S. 67 was resistant in the U.S.A. and India. In Japan it was susceptible in only one of the 5 tests carried out. Raminad Str. 3 was resistant both in India and the Philippines but susceptible in Japan.

From the above summary of results, it is seen that several varieties which by the above method appeared as susceptible in Japan are resistant according to the evaluation of the Japanese scientists. In view of the very favourable conditions for development of blast occurring in Japan, the working standard of resistance aimed at in Japan is lower than that adopted in other countries.

The differential reaction of the *japonica* rices included in the test points to the possibility of the existence of physiologic specialisation in the pathogen. This question of physiologic specialisation of the pathogen needs very intense study to base the breeding programmes on a sound footing. This could be taken up on a countrywide or on a regional basis at Centres where such facilities exist. The work to be done mainly is collection of as many isolates as possible from different parts of the country and testing them against a set of standard differentials. Evidence that physiologic races of the blast pathogen occur has been obtained in Japan and the U.S.A. In India the work done so far shows that races which vary in their virulence do occur in the country.

An exchange programme of resistant varieties between different countries holds out promise of fruitful results since well-known resistant varieties of one country like Raminad Str. 3 of the Philippines, Bengawan of Indonesia and S. 67 of India and Chianongyo-280 of Taiwan have consistently proved to be resistant. The remarkable correspondence of the reaction of the well-known susceptible varieties (Mas, Co. 13, Thailand and Fortuna) may also be mentioned here.

COOPERATIVE RICE VARIETY TRIALS IN TAIWAN, 1956-58

T.T. Chang[1]

I. Introduction

The possibility of undertaking cooperative variety trials on an international basis was first discussed at the fifth meeting of the Working Party on Rice Breeding, the International Rice Commission of the FAO, held in Tokyo during 1954. The working plan was drawn up at the sixth meeting held at Penang in 1955. Varieties listed under Maturity (sowing-harvest) Groups 1 (85-100 days), 2 (120 days) and 3 (130-140 days) were suggested by JCRR and duly supplied by FAO. The field testing work was undertaken by the Taichung District Agricultural Improvement Station in Taichung City under the joint supervision of the Taiwan Agricultural Research Institute and the JCRR. The testing covered four crops: the second crop of 1956 (referred to herein as 1956-II), the first crop of 1957 (1957-I), and the second crops of 1957 (1957-II) and 1958 (1958-II), respectively.

II. Materials and Methods

During July and August of 1956, twenty-five varieties were received from the FAO, among which six varieties failed to reach the initial testing in 1956-II either because of insufficient seed or poor seed viability. Another eight varieties from Pakistan arrived too late for the test in 1956-II. All the varieties from Pakistan failed to germinate in 1957 and were excluded from the trials.

The above-mentioned 25 varieties are listed as follows:

A. Group 1. Very early varieties (85-100 days) — 10 varieties

Country	Varieties and degrees of latitude			
	10-15	15-20	20-25	25-30
India	Asd 8 Ptb 10 Tkm 3	Kolamba 184	Dular Ch. 2 Ch. 45 Ch. 47	Kaladumai T. 136

B. Group 2. Early varieties (120 days) — 5 varieties

Country	Varieties and degrees of latitude			
	10-15	15-20	20-25	25-30
India	Asd 2 Adt 16 Adt 20		Ch. 62	
Thailand		Rak Pai		

1 Senior Agronomist, Plant Industry Division, Joint Commission on Rural Reconstruction, Taiwan.

C. Group 3. Medium early varieties (130-140 days) – 10 varieties

Country	Varieties and degrees of latitude				
	0–5	10–15	15–20	20–25	25–30
India		Ptb 2 Asd 5	Kolamba 540 Mtu 3	Jhanji 34 BR. 4 T. 1145	T. 3
Philippines		Milfor			
Malaya	Radin-Kling				

Three Taiwan varieties, namely, Taichung 65 (*japonica*), Kaohsiung 27 (*japonica*) and Bir-me-fen (also known as Pebifun or Pei-mi-fun, *indica*) were entered in the same series of trials, with Taichung 65 as the standard or check variety. All the three varieties belong to Maturity Group 2. Taichung Special 6 (*japonica*, about 105 days) and a line from the National Taiwan University (NTU Line 1016, *indica*, about 110 days) were included in 1957. Taiwan is located at 21-25° N.; Taichung, 24° 15'.

The experimental design adopted was a randomized complete block design, replicated 3-4 times, with 5-row plots. The row and hill distances were 22.5 cm. in 1956, and 25 cm. in 1957 and 1958. Five seedlings were transplanted to each hill and 20 hills made up a row. The rate of manuring followed the standard practice in Taichung Station: 11 (N) - 11 (P) -11 (K) kg./ha. for the seedbed, and 80-54-46 kg./ha. for the field.

The yield testing for 1956-II was divided into two trials according to maturity grouping to accommodate the large number of entries. Testing in both crop seasons of 1957 was planned. However, experience with cold injury to seedlings during 1957-I forewarned further testing in the first crop season unadvisable. The testing in 1958 was therefore limited to the second crop.

For trials in the second crop, sowing was made during July and transplanting at 15-20 days later. Harvesting was made during October and November. For 1957-I, sowing was made in January and harvesting in June.

Data were collected on seed viability, plant height, foliage color, tillers per hill, date of heading, date of maturity, panicles per hill, straw strength, shattering habit, color and quality of rough (brown) rice, pest incidence, thousand kernel weight and grain yield.

Varieties which could not be included in the yield trials for various reasons are listed under Table I.

III. Experimental Results

The relevant agronomic data and yield figures for the four crop seasons are given in the Appendix: Tables II (1956-II, Group 1) and III (1956-II, Group 2). Since the seasons of 1957-II and 1958-II included an identical set of entries, the plot yields for the two seasons have been combined and presented in Table IV. A prior test of homogeneity of variances for the two crops have indicated that the two sets of data may be pooled.

It is noted that in all the five yield trials, either Taichung 65 or Bir-me-fen led the entries in grain yield. Taichung 65 was the leading variety in all the four second-crop trials, while Bir-me-fen led the field in 1957–I. Among the introduced varieties, Asd 2 was the leading contender among the foreign entries in 1956–II and 1957–I. However, Asd 2 lost its eminence during 1957–II and 1958–II. Ch. 62 compared favorably with the lower yielding one of the two check varieties during 1957–I, 1957–II and 1958–II. Ch. 2, also from India, competed with Bir-me-fen during the second crops of 1957 and 1958. Milfor performed well during 1956–II and 1958–II, but very poorly in 1957–II. Jhanji 34 yielded well during 1956–II and 1957–II, but fairly well in 1958–II. Kaladumai performed consistently poorly in all the trials concerned. All the other introduced varieties showed a variable pattern of performance in the crop seasons mentioned above.

The analyses of variance for each of the five yield trials are summarized as follows:

Source of variation	1956-II-Gp. 1 df	1956-II-Gp. 1 M.S.	1956-II-Gp. 2 df	1956-II-Gp. 2 M.S.	1957-I df	1957-I M.S.	1957-II df	1957-II M.S.	1958-II df	1958-II M.S.
Replicates	3	7,799	3	7,450	2	2,425	3	18,036*	3	7,407
Varieties	14	247,182**	10	210,089**	16	153,692**	21	146,418**	21	256,836**
Error	42	4,891	30	3,949	32	3,338	63	6,442	63	8,441

* Significant at the 5% level.
** Significant at the 1% level.

The mean squares due to varieties are significant at the 1% level in all cases. The mean squares due to replicates are significant at the 5% level during 1957-II only. The pooled plots yields for 1957-II and 1958-II are analyzed and presented below.

Source of variation	d.f.	Mean squares	Estimate of
Years	$1=(y-1)$	1,566,059**	–
Replicates in years	$6=(r-1)y$	12,721	–
Varieties	$21=(v-1)$	300,371**	$\sigma^2 + r\,\sigma^2_{V\times Y} + ry\,\sigma^2_V$
Varieties × years	$21=(y-1)(v-1)$	102,883**	$\sigma^2\ r + \sigma^2_{V\times Y}$
Error	$126=y(r-1)(v-1)$	7,441	σ^2

** Significant at the 1% level.

The above analysis indicated that, in addition to varietal differences, the effects of years and that of the variety x year interaction are also noteworthy.

By extrapolating the components in the above mean squares under the random model (Model II), estimates for $\sigma^2_{V\times Y}$ and σ^2_V are obtained. The heritabitity estimate (in the broad sense) for the variety means is calculated at 78.13%.

It was noted during the seedbed culture in 1957-I that the seedlings of

Ptb 10, Tkm 3 and Ch. 62 appeared to be more tolerant to low temperatures, whereas those of Kaladumai appeared to be the most susceptible ones among the 17 entries for that crop season. The seedlings of Dular, Ptb 2, Milfor, Kolamba 540, Mtu 3, Jhanji 34, BR. 4, T. 1145 and T. 3 were largely killed by low temperatures, and those varieties were not entered in the yield trial for that season.

In terms of maturity, with a few exceptions, most of the introduced varieties in Maturity Groups 1 and 2 matured earlier or about the same time in the three second-crop seasons as Bir-me-fen. The exceptions were Ch. 47 in the 85-100-day Maturity Group, Rak Pai in the 120-day Group, and T. 3, Milfor and Radin Kling in the 130-140-day Group. Jhanji 34 of the 130-140-day Group matured even earlier than the check varieties in most of the cases. For the first-crop season of 1957, with the exception of Ch. 47, all the introduced varieties matured earlier or about the same time as the two check varieties.

In other aspects, all the *indica* varieties gave taller growth and lodged badly. The *indica* varieties likewise showed a more serious preharvest shattering. The kernels of all *indica* varieties scored a lower thousand kernel weight than Taichung 65, though there appeared to be considerable seasonal variations. The rice kernels of Asd 8, Kaladumai, Ptb 10 and Jhanji 34 were colored (red); that of Dular, light red. All the other varieties had white kernels.

Little was known about the disease resistance or insect resistance of introduced varieties under Taiwan conditions, since no outbreak of disease or insect was noted.

VI. Discussion

A. Twenty-five rice varieties from India, Thailand, Malaya and the Philippines supplied by the FAO were entered in five yield trials held during 1956-II, 1957-I, 1957-II and 1958-II. Five entries from Taiwan, 3 *japonica* and 2 *indica*, were included. Taichung 65 and Bir-me-fen were taken as the check varieties. The number of entries in each trial varied with the occasion, depending on the availability of normal-growing seedlings for each entry concerned. All the varieties included were allegedly in Maturity Groups 1, 2 and 3. The yield trials were conducted at the Taichung District Agricultural Improvement Station in Taichung City.

B. With the exception of Rak Pai (Thailand) and Radin Kling (Malaya), most of the introduced varieties were able to mature within the prevailing growing season at Taichung as long as sensitivity to photoperiod was not a critical factor in affecting seedset.

C. All the introduced varieties gave taller plants and more vigorous vegetative growth than Taiwan's *japonica* varieties. All the foreign varieties lodged badly and shattered readily, which undesirable features are often associated with *indica* varieties.

D. Five of the foreign varieties have colored (red) kernels. Colored kernels are considered as undesirable in Taiwan's rice market.

E. The grain quality of all introduced varieties was considered inferior to Taiwan's varieties, either *japonica* or *indica*.

F. Nearly one half of the introductions were susceptible to cold injury due

to low temperatures. Thus, they can only be grown in Taiwan as the second crop or the intermediate crop.

G. The 'among varieties' mean squares for all five yield trials were significant at the 1% level. In all the trials, either Taichung 65 or Bir-me-fen topped all the others. Bir-me-fen gave better performance in the first crop, and Taichung 65 in the second crop. Among the introductions, Asd 2, Ch.2, Ch. 62 and Jhanji 34 from India and Milfor from the Philippines trailed closely behind the checks in some of the trials. Their performances in different seasons showed considerable variation. The same may be said for the lower yielding ones. Kaladumai from India yielded consistently lower than others.

H. For the pooled data from 1957-II and 1958-II, the mean squares due to 'years', 'varieties' and 'years x varieties' were significant at the 1% level, indicating that seasonal effects and the differential performance of varieties in different seasons are worthy of attention. Yield trials repeated over several seasons appear to be a necessity.

I. To obtain maximum precision from similar experiments involving little-known introductions, prior observation appears advisable to minimize 'missing' plots, either due to cold damage or over-late maturity.

J. While the introductions appear to offer little in terms of grain yield to Taiwan's existing rice varieties, they still appear promising as breeding stocks in other aspects. The introductions may be useful in providing resistance to certain diseases or insects, the potentiality of which has not been fully explored so far.

Summary

Twenty-five varieties in the 85–140 day maturity range from India and the Philippines were tested in Taiwan during 1956–58 (4 crop seasons) in comparison with Taiwan's varieties. Nearly all the introduced varieties matured within the growing season prevailing at Taichung City. Wide differences in grain yield were observed among the entries. None of the introductions surpassed the higher yielding one of the two check varieties, Taichung 65 (*japonica*) and Bir-me-fen (*indica*), in any of the seasons tested. Among the introductions, Asd 2, Ch. 2, Ch. 62 and Jhanji 34 from India and Milfor from the Philippines gave comparably high yields in some of the seasons, but failed to perform equally well in all the seasons. The 'years x varieties' mean squares for the second crop seasons of 1957 and 1958 are significant at the 1% level. All the foreign introductions lodge badly and shattered readily. All introduced varieties possess grain quality inferior to those of Taiwan's varieties. The potential value of these introductions as sources of disease resistance remains to be determined.

Appendix

TABLE I

List of Foreign Rice Varieties Failed to be Entered or Recorded in Certain Yield Trials for Specific Reasons as Given Below

Variety and origin	1956–II	1957–I	1957–II
1. Asd 5 (India)		No seedset in 1956–II.	No seed supply.
2. BR. 4 (India)		Seedlings mostly killed by low temperatures.	No seedset in 1957–I.
3. Ch. 2 (India)	Low seed viability.		
4. Dular (India)		Seedlings killed by low temperatures.	
5. Jhanji 34 (India)		Seedlings mostly killed by low temperatures.	
6. Kolamba 540 (India)		,,	,,
7. Mtu 3 (India)		,,	,,
8. Ptb 2 (India)		,,	,,
9. T. 3 (India)		,,	,,
10. T. 1145 (India)		,,	,,
11. Tkm 3 (India)	Low seed viability.		
12. Radin Kling (Malaya)		Over-late in maturity.	Propagated by Kaohsiung Sta.
13. Milfor (Philippines)		Seedlings mostly killed by low temperatures.	
14. Rak Pai (Thailand)		Over-late in maturity	,,
15. Boro 5 (Pakistan)	Late arrival of seed.	Seeds failed to germinate.	
16. Boro 8 (Pakistan)	,,	,,	
17. Dalashaita (Pakistan)	,,	,,	
18. Dharial (Pakistan)	,,	,,	
19. Johna (Pakistan)	,,	,,	
20. Kangni (Pakistan)	,,	,,	
21. Kumari (Pakistan)	,,	,,	
22. Palman (Pakistan)	,,	,,	

TABLE II

Agronomic Data of 19 Varieties in Group 1 of 1956-II[1]

Variety	No. of panicles per hill 1956-II	1957-I	Maturity Period (Sowing-Heading) No. of days 1956-II	1957-I	Lodging	Shattering	Mean grain yield/plot 1956-II	1957-I	Rough Rice Colour	Quality
1. Asd 8	17.7	16.6	71	114	Bad	Easily	657.5	733.3	Red	V. poor
2. Ptb 10	16.6	13.8	80	123	,,	,,	1016.0	779.6	,,	,,
3. TKM 3	x	19.5	—	120	,,	,,	—	492.0	White	Fair
4. Kolamba 184	14.5	16.5	78	119	,,	,,	680.0	605.9	,,	,,
5. Dular	13.6	—	73	—	,,	,,	792.8	—	—	—
6. Ch. 2	—	14.7	—	106	Slight	,,	—	244	,,	,,
7. Ch. 45	18.7	17.4	77	118	,,	,,	876.5	879.9	,,	,,
8. Ch. 47	17.3	14.7	88	129	Bad	,,	794.0	570.3	,,	Poor
9. Kaladumai	20.0	17.5	71	110	,,	,,	258.0	322.0	Red	V. Poor
10. T. 136	15.6	15.0	76	115	,,	,,	788.0	383.6	White	Fair
11. Asd 2	20.0	17.5	83	121	,,	,,	1075.5	882.6	,,	,,
12. Adt 20	20.0	17.5	77	122	,,	,,	754.8	581.9	,,	,,
13. Adt 16	18.2	21.2	79	123	,,	,,	841.3	446.3	,,	M. good
14. Ch. 62	—	19.3	—	121	,,	,,	—	857.9	,,	Fair
15. Rak Pai	13.7	—	123	—	,,	,,	—	—	—	—
16. Taichung 65	16.8	15.2	83	123	Slight	Little	1245.5	812.2	,,	Good
17. Kaohsiung 27	15.9	14.7	86	123	,,	,,	1183.8	856.2	,,	,,
18. Taichung Sp.6	15.0	18.4	66	112	,,	Some	625.3	749.9	,,	,,
19. Bir-me-fen	14.9	19.7	81	121	Bad	Easily	1031.8	1031.9	,,	M. good

1 Experimental material sown on July 11, transplanted on July 27.

TABLE III

Agronomic Data of 13 Varieties in Group 2 of 1956-II[1]

Variety	Maturity Period (Sowing-Heading) days	Lodging	Shattering	Mean grain yield/plot (gm)
1. Radin Kling	131	None	Easily	—
2. Ptb 2	105	Badly	,,	611.0
3. Asd 5	181	—	—	—
4. Milfor	100	None	Easily	957.0
5. Kolamba 540	91	Badly	,,	671.0
6. Mtu 3	98	,,	,,	755.3
7. Jhanji 34	84	,,	,,	956.5
8. BR. 4	102	,,	,,	732.0
9. T. 1145	105	,,	,,	651.8
10. T. 3	88	,,	,,	857.3
11. Taichung 65	84	Slightly	Little	1,324.0
12. Kaohsiung 27	84	,,	,,	1,185.0
13. Bir-me-fen	82	Badly	Easily	1,089.5

1 Experimental material sown on July 11, transplanted on July 27.

TABLE IV

Agronomic Data of 22 Varieties in 1957-II and 1958–II Trials

Variety	Maturity Period (Sowing-Heading) days 1957-II	1958-II	Mean Yield/plot (Gm) 1957-II	1958-II	Lodging	Rough Rice Colour	Quality
1. Asd 8	78	78	815.31	671.0	Bad	Red	Poor
2. Ptb 10	84	84	889.8	1001.3	,,	,,	,,
3. Tkm 3	83	79	903.01	804.5	,,	White	Fair
4. Kolamba 184	86	81	607.8	934.5	,,	,,	,,
5. Dular	80	78	600.8	860.8	,,	Lt. red	Poor
6. Ch. 2	78	78	969.3	1186.8	,,	White	Fair
7. Ch. 45	79	79	979.0	1024.5	,,	,,	,,
8. Ch. 47	88	93	673.8	871.3	,,	,,	,,
9. Kaladumai	77	73	480.5	395.3	,,	Red	Very poor
10. T. 136	79	74	653.5	876.5	,,	White	Fair
11. Asd 2	88	87	777.0	1013.5	,,	,,	,,
12. Adt 20	83	82	928.0	809.8	,,	,,	,,
13. Adt 16	85	81	544.5	1042.8	,,	,,	,,
14. Ch. 62	83	79	987.0	1262.8	,,	,,	,,
15. Milfor	99	91	454.8	1160.3	None	,,	,,

TABLE IV (contd.)

Variety	Maturity Period (Sowing-Heading) days 1957-II	1958-II	Mean Yield/plot (Gm) 1957-II	1958-II	Lodging	Rough Rice Colour	Quality
16. Jhanji 34	84	84	1008.3	861.3	Bad	Red	Poor
17. T. 3	87	91	823.3	1139.8	Slight	White	Fair
18. NTU line 1016	79	79	959.5	1207.0	,,	,,	Medium good
19. Taichung 65	86	84	1096.5	1540.0	,,	,,	Good
20. Kaohsiung 27	87	85	989.8	1444.3	,,	,,	,,
21. Taichung Sp. 6	72	70	836.0	876.5	Slight	,,	Medium good
22. Bir-me-fen	83	81	1022.0	1165.8	Bad	,,	Fair

RICE CULTURAL TECHNIQUE AND FUTURE RICE PROBLEMS IN JAPAN

K. Amatatsu[1]

According to the report on rice crop estimates as of September 5, 1960, the index of paddy field rice crop is 109 while that of upland rice crop is 101 (average year's rice crop = 100). The total rice crop in Japan is estimated at 12,940,000 tons of husked rice. The rice crop index for each year from 1955 to 1960 is given below:

Year	Index
1955	122
1956	107
1957	115
1958	116
1959	121
1960	109

Paddy field rice yield for the 1960 rice year was estimated at 4010 kgs. per ha. So far, this is the highest record. A brief review is presented on the advances made in rice cultural technique as well as on the future prospects in rice production.

Paddy Rice Field Improvement. Paddy rice field improvement programs have been carried on continuously. The total acreage of the fields which were improved during the period 1954 to 1958, amounted in the aggregate to 1,593,300 ha. The major land improvement program is concerned with irrigation, drainage and land consolidation. Improvement in irrigation has facilitated the adoption of the practice of timely rice transplanting and has enabled to tide over the dry spell periods. Improvement of water-logged paddy rice fields by suitable drainage systems has contributed to the better and more effective use of fertilizers.

Rice Varieties. Marked changes have taken place in rice varieties during the past several years. Throughout the country as a whole, with the development of new cultural techniques, late-maturing and long-term varieties are now considered less useful, while early and medium maturing ones with high yields are becoming more important. The above trend is particularly noticeable in the cool areas where early transplanting is practised as well as in the warm areas where early seasonal cultivation has come into vogue. At the same time, with the increased amount of fertilizer application, rice varieties with high fertilizer response have become important. Consequently, early and medium maturing rice varieties of high fertilizer response with high yields have become popular to a considerable extent. Among the typical varieties are: Towada, Fujisaka No. 5, Sasashigure, Norin No. 17, Honen-wase, Koshiji-wase, Ginmasari, Norin No. 29 and Kinmaze.

Typical high yielding rice varieties prevalent in the respective prefectures are the following:

1 Project Leader for Rice, Ministry of Agriculture and Forestry, Japan.

Variety	Prefecture	% of area under cultivation
Towada	Aomori	58.1
Sasashigure	Miyagi	53.5
Ginmasari	Chiba	25.4
Norin No. 1	Nagano	25.4
Koshiji-wase	Niigata	17.4
Honen-wase	Fukui	24.8

The demand for superior quality rice varieties is expected to increase in the future in view of the recent trend in quality requirements. Nevertheless, early and medium maturing rice varieties of high fertilizer response with high yields will still continue to be important. Moreover, disease-resistant varieties, varieties suitable for early seasonal culture and varieties suitable for direct sowing will also be required. All these requirements will have to be considered in the future rice breeding programs.

Paddy rice varieties bred and registered officially for the past 10 years amounted to as many as 71 varieties. When the rice varieties selected at the prefectural experiment stations are included, the selected rice varieties would be still more. In view of the increasing interest taken by the farmers in rice varieties, the future breeding program should take into account the farmers' requirements.

Production of Healthy Rice Seedlings and Shift of Cultural Seasons

The program for the production of healthy rice seedlings was initiated in 1949 by the Ministry of Agriculture and Forestry. Since then the area of paddy rice fields transplanted to rice seedlings, raised in protected rice nurseries, has increased to approximately one million hectares in 1959. The production of healthy rice seedlings has contributed a great deal to improved rice culture and the use of such seedlings in the early transplanting practice has increased the efficiency of rice production. Such early transplanting has become popular in the cool regions of the country as well as in the intermountain warm areas. By the adoption of this practice in cool region, the risk of damage by cold spells during heading and maturation stages of rice growth has been avoided and higher production with heavier application of fertilizers has been ensured. This has been demonstrated by experimental results as well as in the achievements of the "best in Japan" rice cropping contest. In the warmer part of the country, earlier transplanting has led to early harvest before August-September and thus the risk of damage by typhoons which generally sweep over the country during September has been avoided and has also led to the improvement of the fields subject to autumn decline "Akiochi", drought, etc.

The early seasonal cultural practice has now spread over nearly one third of the total acreage and it is expected that the area under this practice will continue to increase with the advances in technical improvements in the control of insect pest and diseases, rice quality, etc.

Increase in Fertilizer Application and Improvement of Fertilizer Application Methods

In recent years, the amount of fertilizer used on paddy rice showed an increase, particularly so in the Tohoku, Hokuriku and Tosan Districts.

TABLE I

Changes in the Amount of Fertilizer Application

(*kgs per hectare*)

District	N		P_2O_5		K_2O	
	1954	1958	1954	1958	1954	1958
Hokkaido	41.6	53.6	46.9	57.7	34.1	47.4
Tohoku	63.8	82.1	41.6	61.6	44.3	74.4
Kanto	63.8	70.0	50.6	63.4	49.5	60.2
Hokuriku	60.0	90.4	33.4	56.6	46.5	85.7
Tosan	70.9	84.6	51.0	45.1	53.3	62.5
Tokai-Kinki	55.1	66.7	34.5	45.7	45.8	56.0
Chugoku	45.8	67.5	25.1	37.4	42.4	65.2
Shikoku	44.3	66.0	32.6	45.5	46.1	62.6
Kyushu	60.0	67.6	38.6	43.3	37.5	46.8

The consumption of each of the three nutrient elements is on the increase. This can be ascribed to factors such as land improvement, farmers' improved practices of fertilizer application, and the rapid spread of the early seasonal cultural practice. Such improved conditions for the rice cultural practice with heavy fertilizer application have contributed greatly towards the increase in rice production.

The improvement of fertilizer application practices at experimental stations or by practical farmers should not be overlooked. Experiments have been conducted based upon soil conditions and rice plant requirements, and a rapid progress has been made in farmers' split application practices. The fertilizer application improvement programs worked out in 1953 have been carried on steadily. The total acreage of paddy rice fields under the improved methods of fertilizer application reached 960,000 hectares in 1959.

Spacing (density of hills)

Early seasonal rice cultural practice or heavy fertilizer application has led to modifications in the spacing of hills. According to the results of various experiments, it is clear that the number of panicles per unit area is a deciding factor affecting rice yields. In the high yielding paddy fields, the number of panicle per *Tsubo* (3.3^2 sq.m) amounts to 1800. There is a fair possibility of this being increased as compared with the present number of panicles which is closely related with the density of transplant seedlings of rice. From the following table, the number of hills per *Tsubo* is found to be increasing in most of the rice areas in the country.

TABLE II

Changes in the Number of Hills per Tsubo of the Paddy Rice Fields which served as the Sample Fields for the Rice Crop Estimates

Prefecture	1953	1955	1957	1959
Sapporo	65.3	63.5	65.8	66.0
Aomori	81.9	80.1	80.2	79.8
Fukushima	58.7	59.5	60.8	61.7
Ibaragi	72.3	71.2	68.9	67.9
Chiba	62.2	61.2	62.5	65.2
Niigata	54.0	54.1	55.7	57.1
Fukui	60.0	59.9	60.7	63.4
Nagano	66.1	65.8	68.1	69.8
Aichi	48.4	49.9	54.5	58.5
Hyogo	49.8	50.0	52.3	53.8
Shimane	63.3	62.6	62.5	63.6
Hiroshima	57.5	57.8	58.6	61.6
Kagawa	46.3	46.4	46.6	48.6
Kochi	61.2	60.6	61.4	61.1
Fukuoka	52.7	54.4	55.8	57.8
Kagoshima	57.4	57.2	58.2	59.7

Disease and Insect Pest Control

Though the acreage of rice area affected by diseases and pests has not diminished by the adoption of the improved cultural practices and fertilizer applications, the incidence or damage per unit area is much less than before because of impoved control methods. The decrease in rice yields due to damage by insects and diseases was 390 kgs. of rice per ha. in 1950-54 while it was only 190 kgs. in 1955-59.

Improvement of Efficiency in Rice Cultural Operations

The labour productivity is now improving with the introduction of power tillers, power sprayers, dusters, and weed-killers in paddy rice culture.

TABLE III

Number of Farm Power Machines owned by Farmers (in 1,000 units)

Year	Motors	Engines	Power tillers	Power sprayers	Power threshers	Power huskers
1942	145	317	* 3	5	357	180
1947	287	229	8	7	444	199
1953	810	642	35	44	1,269	540
1955	956	1,134	82	76	2,038	696
1958	1,042	1,525	338	168	2,343	711

Note: * indicates the figures in 1939

Farmers can consequently afford to implement technical improvements. They are now paying frequent visits to experiment stations or to rice expert farmers. It is possible to reduce the required labour to 100 or less men-hour per hectare. Weed killers are now in wide use, in about 30% of the total paddy rice acreage. Moreover, deep-tillage with large size machines is also coming into practice.

Discussions (Appraisal of the Technical Effects)

The increase in the level of paddy rice yields is due to many factors. It is not easy to assess the contribution of a single individual factor in view of the fact that in most cases the combination of two or more factors bring about the desired results. In addition to improved techniques, land reform program, agricultural extension services and price levels are some of the major contributing factors. The improvement effected by all the above factors can be termed "technical effects". This is derived by eliminating the effects due to weather conditions. The differences between the yearly average rice yields surveyed by the Statistics and Survey Division (Ministry of Agriculture and Forestry) and the yields derived from the weather response tests carried out throughout the country can be considered as effects due to technical improvement.

As given in the table, the technical effects in the consecutive years from 1954 on show an upward trend: i.e., 5% (1954), 12% (1955), 6% (1956), 8% (1957), 10% (1958), and 16% (1959). Out of the eight ecological districts, the Tohoku, Tosan, Hokuriku, and Shikoku Districts are leading in technical effects.

TABLE IV

National Average Rice Yield per ha. and Rice Yield under the Weather Response Tests

		1949–52	1953	1954	1955	1956	1957	1958	1959
National average rice yield per ha.	Yield (kgs.)	3240	2690	3190	3960	3460	3730	3760	3910
	Index (A)	100	83	99	122	107	115	116	121
Rice yield under the weather response tests (national average)	Index (B)	100	92	94	110	101	107	106	105
Technical effect index	(A)-(B)	0	-9	5	12	6	8	10	16

Future Problems

Reviewing the progress of the technical development from the past, it appears that in the future, further expansion in technical progress is quite possible. However, it is not easy to estimate the increase in rice yield that can be effected in future years, as in addition to technical problems, other factors such as the future rice policy of the Government and the possible

changes in rice requirements of the people are involved.

The conclusion has been drawn by the Agriculture-Forestry and Fisheries Fundamental Problems Investigation Council that rice yield per hectare in the 1969 Rice Year will increase to 4120 kgs. from 3700 kgs. in the 1958 Rice Year, equivalent to 11.3% increase. On the other hand, from the standpoint of technical improvement, the Agriculture-Forestry and Fisheries Technological Council believes that the average per hectare yield may be raised to the level of 4500 kgs. in the course of the next 10 years. Reviewing the present progress, it would be by no means impossible to set up a target yield of 4500 kgs. per hectare. When this hectare yield is attained, the present total production of rice of 13 million tons can be obtained from the paddy rice fields of three million hectares. The remaining area under paddy rice fields can then be converted into upland fields. Forage crops namely, clovers, chinese milk vetch, soya bean, oats, barley, etc. can easily be raised on these fields.

The improvement of paddy rice field soils is important in the stepping up of rice yields. Paddy rice fields in Japan are superior to other farmlands and higher in productivity. It is therefore necessary to improve paddy rice field soils in order to increase land productivity. When paddy rice fields are tilled deeper and brought under drainage, further increase in rice production is possible. Early transplanting cultural practice or early seasonal cultural practice spreading over nearly one million hectares will also contribute to the rice production increase. Lodging, diseases, or insect pests can be controlled more effectively through the improvement of rice varieties and by the development of more efficient techniques.

The projected rice yield targets at regional agricultural experiment stations are far higher than the yield targetted for the country as a whole, and are estimated at 6000–9000 kg/ha. in order to meet the requirement for high level productivity improvement. At each of the experiment stations, the reduction in labour requirement to 50–66% is aimed at in the case of a transplanting cultural practice and to 5% in the case of a direct-sowing cultural practice.

It is important for farmers to increase rice yields per unit acreage and also to reduce the present labour requirement, and at present it is more urgent to save labour. For there appears no other way to obtain the labour required for initiating horticulture and livestock development, particularly so now when the number of agricultural workers is on the decrease. Therefore, in areas where it is anticipated that some changes may take place in the agricultural structure, it is necessary to devise labour-saving methods and reduce the labour requirement to the extent of 50 per cent without sacrificing the present yields of rice. With the cooperation of agricultural scientists and extension workers, mechanization of rice culture including direct sowing will have to be taken up and pushed forward.

In view of the growing demand for the improvement of rice quality, emphasis has to be placed on selection of good quality varieties as well as on improved methods of drying and storage.

SUMMARY REPORT OF THE 1960 MEETING OF THE WORKING PARTY ON THE AGRICULTURAL ENGINEERING ASPECTS OF RICE PRODUCTION, STORAGE AND PROCESSING OF THE INTERNATIONAL RICE COMMISSION

The first meetiong of the Working Party on the Agricultural Engineering Aspects of Rice Production, Storage and Processing was held in Saigon, Vietnam from 10–15 November 1960 at the kind invitation of the Government of Vietnam. The meeting was attended by 34 participants representing 15 Governments.

The following is a summary of recommendations of the Meeting of the Working Party.

Improvement of Farm Implements for Rice Production

1. To request the Director-General of FAO to recommend to Member Governments of the International Rice Commission to give particular attention to experimental study, trial, development and improvement of farm implements for rice production, hand, animal and power operated.

2. Governments should establish national testing and research centres for such farm implements, or strengthen the means of action of existing centres.

Illustrated Glossary of Farm Implements required for Hand, Animal and Power Use in Rice Production

In view of recent modifications of indigenous implements, the increasing use of relatively new machines and the present cooperation which now exists between Countries, it is necessary that Common Terminology be used.

3. FAO should collect the necessary information and prepare an Illustrated Glossary with suitable terminology.

Regional and Sub-regional Training Centres

4. To request the Director-General of FAO to assist Governments in organizing regional and sub-regional training centres on tools and equipment used in the mechanization of rice culture so that further training in the selection, operation and servicing of such equipment would result.

5. To request the Director-General of FAO to assist Governments in organizing regional and sub-regional training centres in methods and use of equipment for rice testing, and pre-processing operations such as cleaning, grading and drying.

Selected Harvesting and Processing Equipment Trials

6. Governments should conduct trials with selected harvesting equipment. Where possible, trials should also be conducted on processing in small to medium sized mills.

7. FAO should, through its newly appointed Agricultural Engineer for Asia and the Far East, co-ordinate trials and advise and assist Governments in their planning and conduct.

Drying Experiments for Preservation and Milling Yields of Paddy

8. To avoid excessive losses of quality and yield, the Working Party requests the Director-General of FAO to recommend to Member Governments of the International Rice Commission:

(a) to continue and expand experimental work on paddy drying, especially at small farm level and with cooperative paddy storage;

(b) to undertake basic studies on moisture-heat balance during drying and storage.

Such experimental work should be conducted in various environments, but particularly in the tropics, where farmers grow more than one rice crop per year.

General

9. The attention of Governments should be called to the possibility of making use of assistance afforded by the United Nations Special Fund for projects involving research or training designed to solve technical problems. Such demonstration projects should be designed to facilitate further investment.

10. The Director-General of FAO should be asked to request Member Governments of the International Rice Commission to appoint a liaison officer until the next meeting of the Working Party.

Collecting and Dissemination of Information

11. FAO should continue to collect and to disseminate to Member Governments of the International Rice Commission relevant information on subjects related to the activities of this Working Party.

Such information should be made available through Agricultural Development Papers, Informal Working Bulletins, articles to be published in specialized periodicals, and any other means.

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